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# Rossi Alpha Method

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NEN-2

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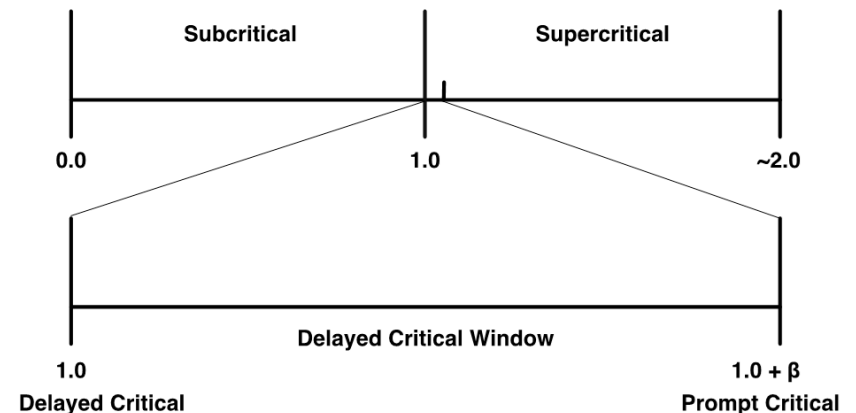
# Overview

- Reactor Physics Parameters
- What is Rossi Alpha?
  - Why we care?
- Classical Experiment
- Modern Experiment
- Experimental Procedure
  - Results of Completed work

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# Reactor Physics Parameters

- Delayed neutrons
- Prompt neutrons
- $K_{\text{eff}}$  the multiplication factor calculates the neutron population change between generations
- $K_p$  is the prompt multiplication factor (i.e. multiplication factor due only to prompt neutrons)



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# Reactor Physics Parameters (cont.)

- $l$  - the neutron lifetime or average time a neutron spends in the media before a terminating event
- $\beta_{eff}$  - delayed neutron fraction
- $\nu_p$  - number of neutrons promptly emitted
- $\Sigma_f$  - macroscopic fission cross section
- Accidental pairs
- Correlated pairs

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# What is Rossi Alpha?

- *Rossi- $\alpha$  is the prompt neutron decay constant.*
- *The prompt neutron decay constant is a good way to calibrate reactivity without use of the Inhour relation*
- *The Rossi Alpha method is useful when establishing the mass increment between delayed critical and prompt critical*

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# Theory

- The probability of detecting two random detection events is:
  - $p_r(t_1, t_2)\Delta_1\Delta_2 = F^2\epsilon^2\Delta_1\Delta_2$
- The probability of detecting a correlated neutron detection event near time  $t_1$ :
  - $p_1(t_1)\Delta_1 = \epsilon v_p v \Sigma_f e^{\alpha(t_1 - t_0)} \Delta_1$
- The probability of detecting a correlated neutron detection event near time  $t_2$ :
  - $p_2(t_2)\Delta_2 = \epsilon(v_p - 1)v \Sigma_f e^{\alpha(t_2 - t_0)} \Delta_1$

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# Theory (cont.)

- The total probability of detecting two correlated neutron counts:

$$- p_c(t_1, t_2) \Delta_1 \Delta_2 = \int_{-\infty}^{t_1} p(t_1) \Delta_1 p(t_2) \Delta_2 F dt_0$$

$$- p_c(t_1, t_2) \Delta_1 \Delta_2 = F \epsilon^2 \frac{D_v k_p^2}{2(1-k_p)l} e^{\alpha(t_2-t_1)} \Delta_1 \Delta_2$$

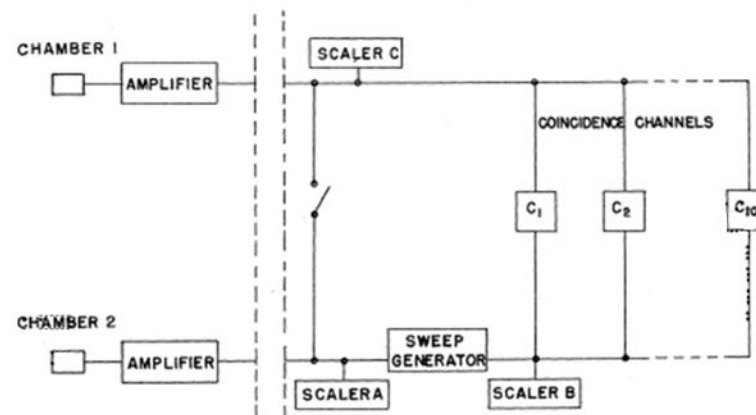
- Add both of these probabilities and combined the constants down into A and B to get:

$$- p(t) = A + B e^{\alpha t}$$

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# Classical Rossi Experiment

- Most notably performed by John Orndoff
- Used a ten channel time analyzer to time discriminate neutron pulses
- Preset Bin widths

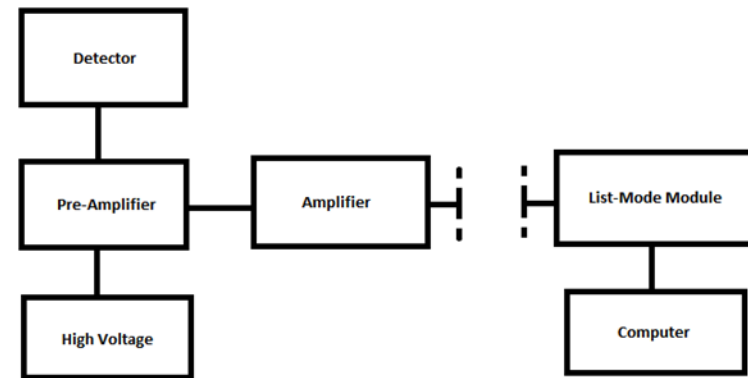


BLOCK DIAGRAM  
10 CHANNEL TIME DELAY ANALYZER

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# Modern Rossi Alpha Experiment

- Uses a List-mode or other piece of hardware capable of time tagging neutron counts
- Has an extra analytical step, but the flexibility to be analyzed in many different ways

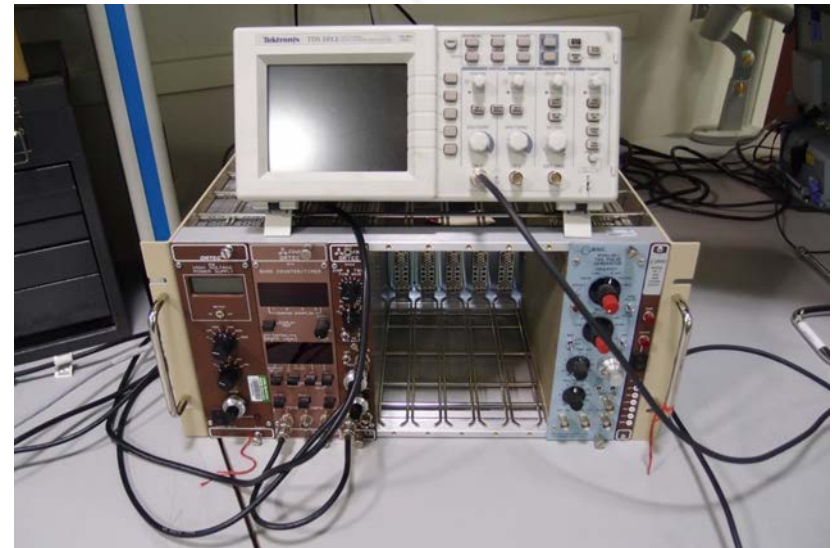


*Experimental Setup at DAF*

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# Experimental Procedure

- Measurements must be performed on a neutron multiplying, chain-reacting system
- Simple counting system is used
- Data is placed into a histogram based to the time differences between neutron detection events

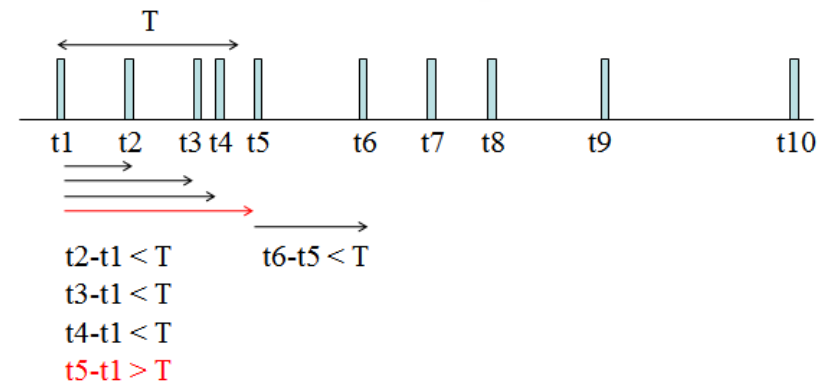


*NIM Bin for the Rossi Alpha experiment*

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# Data Analysis

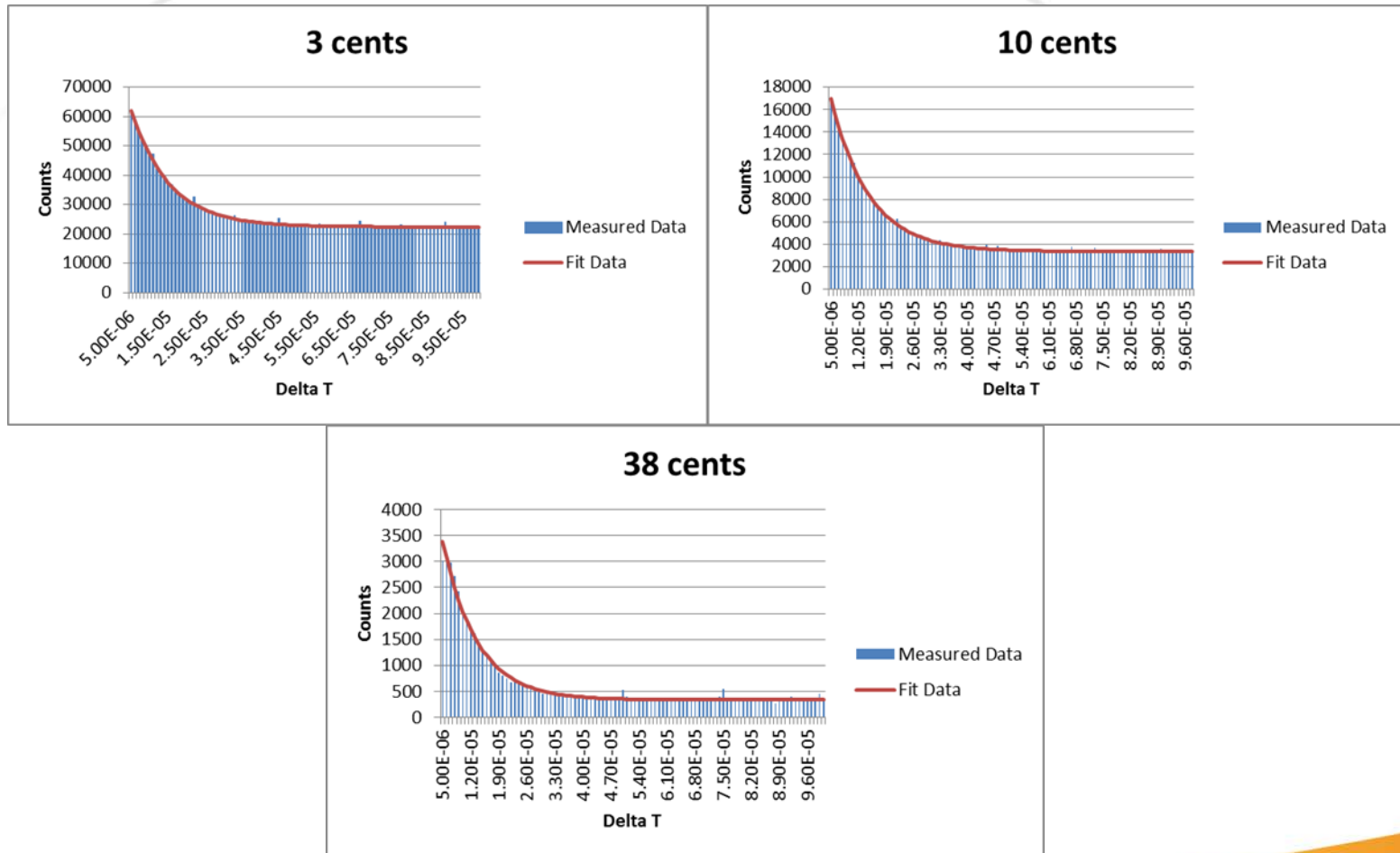
- Heuristic equation developed by Richard Feynman
  - $p(t) = A + Be^{\alpha t}$
  - The A term includes all correlated neutron detection events
  - The B term includes all source neutron detection events (delayed neutrons and other external sources)



*Binning Scheme for Rossi Analysis*

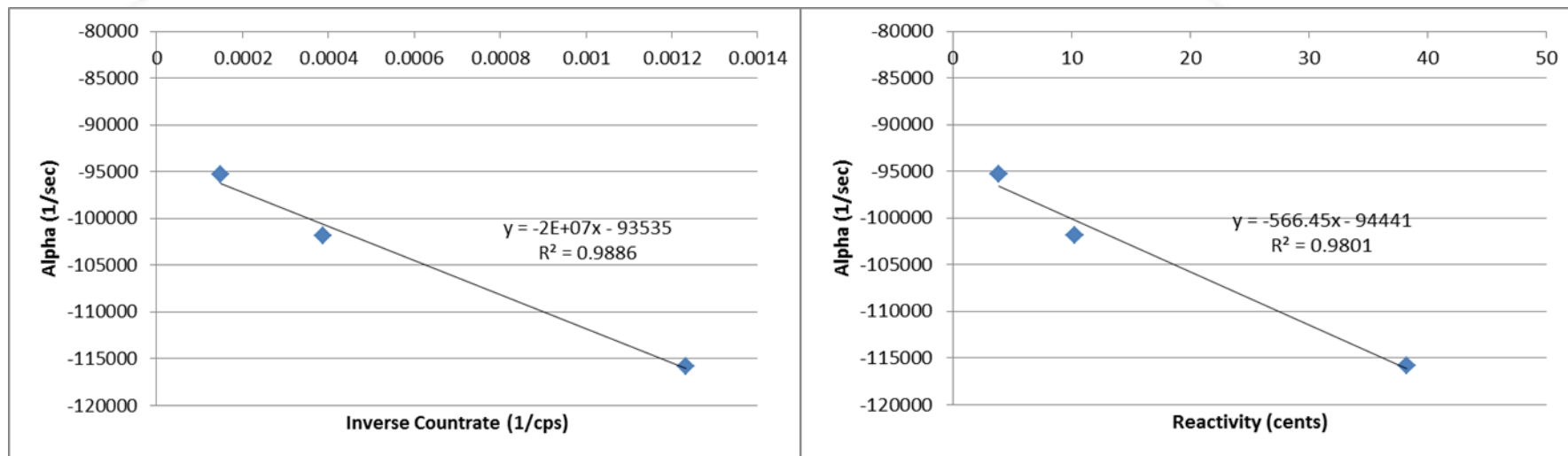
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# Results



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# Results (cont.)



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# Questions and Discussion

- H. C. Paxon and G. E. Hansen, Critical Assemblies and Associated Measurements.
- C. P. Baker, Time scale measurements by the Rossi method.
- R. E. Uhrig, Random Noise Techniques in Nuclear Reactor Systems.
- Ronald.
- J. Orndoff and C. Johnstone, Time scale measurements by the Rossi method.
- F. de Hoffman, Statistical fluctuations in the water boiler and time dispersion of neutrons emitted per fission.
- R. Feynman, Statistical behavior of neutron chains.
- G. E. Hansen, The Rossi Alpha method.
- J. D. Orndoff, Prompt Neutron Periods of Metal Critical Assemblies.
- R.G. Sanchez, G.E. McKenzie, T.J. Grove, and J.A. Bounds, Measurement of the Prompt Neutron Decay Constant in a Highly Enriched Uranium Copper Reflected System.

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